



National Aeronautics and Space Administration

NASA Ames Research Center Research Methods Tutorial

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Tutorial Abstract

Title of Tutorial:

Research Methods

Abstract:

A guiding principle for conducting research in technology, science, and engineering, leading to innovation is based on our use of research methodology (both qualitative and quantitative). A brief review of research methodology will be presented with an overview of NASA process in developing aeronautics technologies and other things to consider in research including what is innovation.

Introductions

Name:

Affiliation: i.e. School, Company, etc.

Interest in this topic: So that I can target my discussion to cover your interests.

A few words before I begin this tutorial

One of my professors (Professor Hamming – IEEE) used to say to his students, “luck favors the prepared mind”.

I would like to add that having an open mind also helps, especially when it comes to research.

Let’s begin this tutorial with some frames of reference and some definitions.

What is meant by research?

To answer this question, let us look at the following three **modes** of research, so that we can put our discussion into a framework.

1. Exploratory Research
2. Descriptive Research
3. Explanatory Research

Exploratory Research

An example of Exploratory Research would be someone going into an unfamiliar society and living there for a period of time in order to understand it through direct experience. Living in an unfamiliar society for a period of time would provide an intriguing look into that society, but this on its own would not provide scientific explanation for anything.

However it could serve as a starting point for a research topic.

Descriptive Research

An example of Descriptive Research would be someone observing and recording the appearance of native birds in a given area, in their natural habitats. An objective of this observation may be one of classification of different birds. While this may be a valuable record and provide a comprehensive picture of the subject, it on its own is not scientific analysis.

Explanatory Research

And Explanatory Research, this area of research uses detection (gathering data and information) in order to find out the truth about something. It goes beyond discovery (exploratory) and classification (descriptive) because it searches for the reasons why something exists.

Explanatory research is the epitome of scientific investigation and the only type of research that can yield results on which predictions may be based.

Explanatory Research

When we encounter an issue that is already known and have a description of it, we might begin to wonder why things are the way they are. The desire to know "why," to explain, is the purpose of explanatory research. It builds on exploratory and descriptive research and goes on to identify the reasons for something that occurs.

Definitions

In conducting Research it is very important to specify the meaning of the terms you are using so that it does not lead to confusion on what is meant.

In Research Methods there are several terms that are well understood and defined in your course books and/or reference books, so when you use words in your research and writing, make certain that it represents your intent.

Definitions

Quantitative research - follows a deductive research process and involves the collection and analysis of quantitative (i.e., numerical) data to identify statistical relations of variables.

Quantitative research methods - research methods that focus on gathering numeric information, or nonnumeric information that is easily coded into a numeric form, such as a survey.

Definitions

Qualitative research - follows an inductive research process and involves the collection and analysis of qualitative (i.e., non-numerical) data to search for patterns, themes, and holistic features.

Qualitative research methods - research methods that focus on gathering nonnumeric information using such methods as focus groups , interviews , document analysis , and product analysis.

The Method of Research

Scientific research means studying something carefully and thoroughly. Using a specific set of rules known since 1854 as the scientific method, it asks and answers questions about the world. The scientific method includes ideals and procedures that guide the preparation and execution of a research design. The ideals are objectivity, or freedom from bias; empirical verification, or checking facts in the real work; contribution to knowledge, or advancing existing knowledge; and publication, or sharing the results with the scientific community.

Procedures are listed on the next page.

Procedures of the Scientific Method

- SPECIFYING GOALS (Ask a question)**
- REVIEWING THE LITERATURE (Do background research)**
- FORMULATING HYPOTHESES (Construct a hypothesis)**
- MEASURING AND RECORDING (Test your hypothesis by doing an experiment)**
- ANALYZING DATA (Analyze your data and draw a conclusion)**
- INVITING SCRUTINY (Report your results,(Was your hypothesis correct?))**

Planning a Quantitative Research Project

Quantitative research begins with a step-by-step plan of how the research will be conducted.

1. The first step involves identifying the research problem.
2. Review or synthesis of the literature relevant to the research problem
3. Develop a hypotheses or research questions.
4. Develop a research approach

Planning a Quantitative Research Project

5. Create a plan for conducting the research.
6. If you are using human subjects, seek approval
7. Collect unbiased data
8. Data analysis
9. Make inferences or interpretations from the data.
10. Communicate findings to the profession.

Research Questions

It's absolutely essential to develop a research question that you're interested in or care about in order to focus your research. For example, researching a broad topic such as "stability and control" is difficult since there may be hundreds of sources on all aspects of stability and control. On the other hand, a focused question such as "What is the static stability of a Puma UAS model xx?" is easier to research and can be covered more fully and in more depth.

Characteristics of a Good Research Question

A good research question is a question that's worth asking. It poses a problem worth solving. A good research question requires more than looking something up. It should force you to weigh evidence and compare divergent data or information on your topic.

It should allow you to develop an answer that your readers find both interesting and significant.

A process for initiating research areas

Next topic in my tutorial is to discuss a process for initiating research.

A process for initiating research areas

I have used scenario based planning to develop aeronautics goals and required technology research areas of opportunity.

In the next few slides, I will go over this process for you to consider as you go forward in your education and or careers.

A process for initiating research areas

In order set the stage for this discussion, I ask you to have an open mind about this topic, because some individuals find this topic less than comfortable for some reason.

A process for initiating research areas

Scenario based planning looks at developing imagined possible future circumstances to encourage innovation and identify research area.

Imagining a future state is the most important element. To begin, clearly state an issue or problem that needs addressing.

This reduces the likelihood of developing scenarios without an intended focus, and ensures we are addressing the correct (intended) problem.

A process for initiating research areas

Characterizing the problem is accompanied by developing objectives, which also clarify understanding of the correct issue or need.

Before you rush into solving problems or making changes, I recommend spending the necessary time to think things through. Peter Drucker cautioned, “The most common source of mistakes in management decisions is the emphasis on finding the right answer rather than the right question.” The same would hold true in technical areas.

A process for initiating research areas

The facilitator must remember that it is not easy to have a group come together and begin to think freely (without bias). He or she must set the stage for proper problem definition and future thinking. The activity takes patience and stamina, as characterizing the problem establishes the foundation for envisioning what could be.

A process for initiating research areas

The process should encourage each participant to dream what is conceivable, because there is a tendency for individuals to use linear thinking rather than imagined possibilities. (this is where some individuals become uncomfortable).

To optimize the process, it helps to bring together individuals from diverse academic backgrounds including non technical individuals (i.e. artists) to generate scenario details that are diverse and innovative.

A process for initiating research areas

Prior to bringing a group together, the facilitator should develop or identify external environment forces information (I will show you an example of this later in my presentation).

This information is a good discussion starting point; it sets the context to address a problem and objectives. Examples might be economic growth or downturn, demographic change, or sustainability concerns.

A process for initiating research areas

So you may be asking yourself at this point, exactly what is scenario based planning?

To me it is generating stories of future imagined states, identified by a brainstorming group, that address the issue and / or objectives identified.

The approach that works best for me, is to limit the number of possible scenarios to two. With limited time or resources, generating stories with this approach is very effective.

A process for initiating research areas

The next set of questions are very important: when does the future state being imagined need to materialize in order to effectively address the issue or problem at hand? Is the time frame realistic?

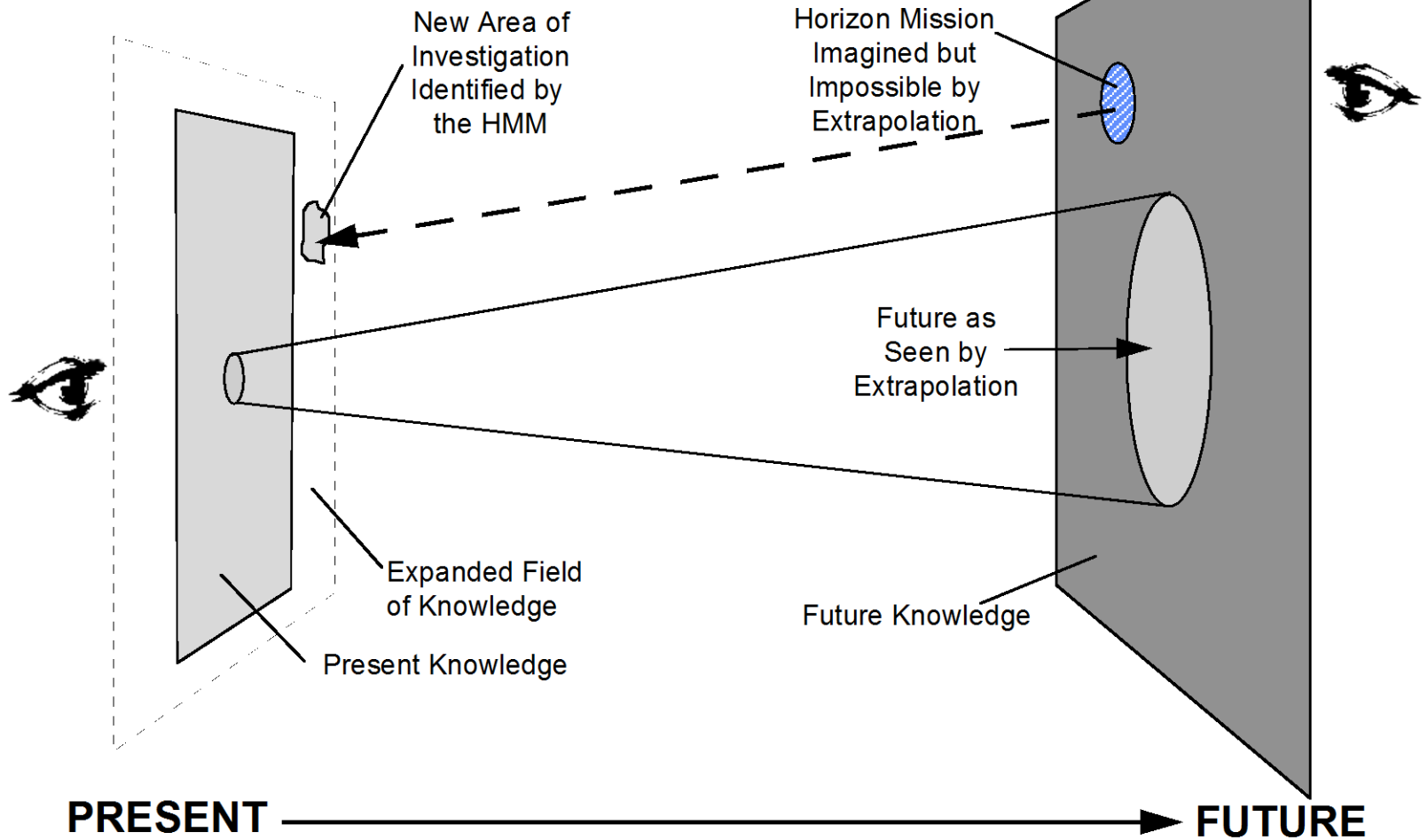
For example it may be realistic to imagine that a future state will happen 5 or 10 years from now. This future state should take into consideration the amount of time needed to develop technologies that currently may not exist.

A process for initiating research areas

After identifying the time frame, the facilitator can graphically depict the scenario(s) on a time-line. The group should imagine themselves as existing in the future, deciding what is actually needed to make the planning real.

Once that takes place, the group must work back from the future, to ask specifically what needs to be developed (technology or policies) today in order to realize the future scenario.

EXTRAPOLATION



UAS Aviation Transportation System

external environment forces

As we begin the 21st century, the dominant mode of global transportation for goods and services will be UAV aviation based. Economic markets continue to expand causing more burden on the existing transportation infrastructure systems.

It is imperative that we maintain the highest level of safety in our National Airspace Systems worldwide.

Let' s think about a

Safe

UAV Transportation System

for the future

Leap Out of the Flashlight Beam

Consider the world in the year 2025 and imagine the safety aspects of a future UAV transportation system.

1) Developing Nations - Invent a safe future UAV transportation system including infrastructure and associated industries given that:

- the future UAV transportation system is pivotal in leapfrogging that country into prosperity by enabling economic, industrial & transportation industries. (Africa?)
- Global economies are extensively intertwined.

2) United States - Design the safest future UAV transportations system of tomorrow, given that:

- the US is transformed by the future UAV system through innovative alliances.
- analogous to the establishment of the US interstate highways.
- the future UAV transportation system is the backbone of future air travel.

Horizon “Mission” #1 - Year 2025

- Global Economies are extensively intertwined (new markets, low cost labor, resources, specialization).
- Many former 3rd world nations are prosperous. This required the establishment of economic, industrial and transportation infrastructures.
- In at least one country, a new airport environment with high capacity has been the pivotal agent in the leapfrogging into prosperity.

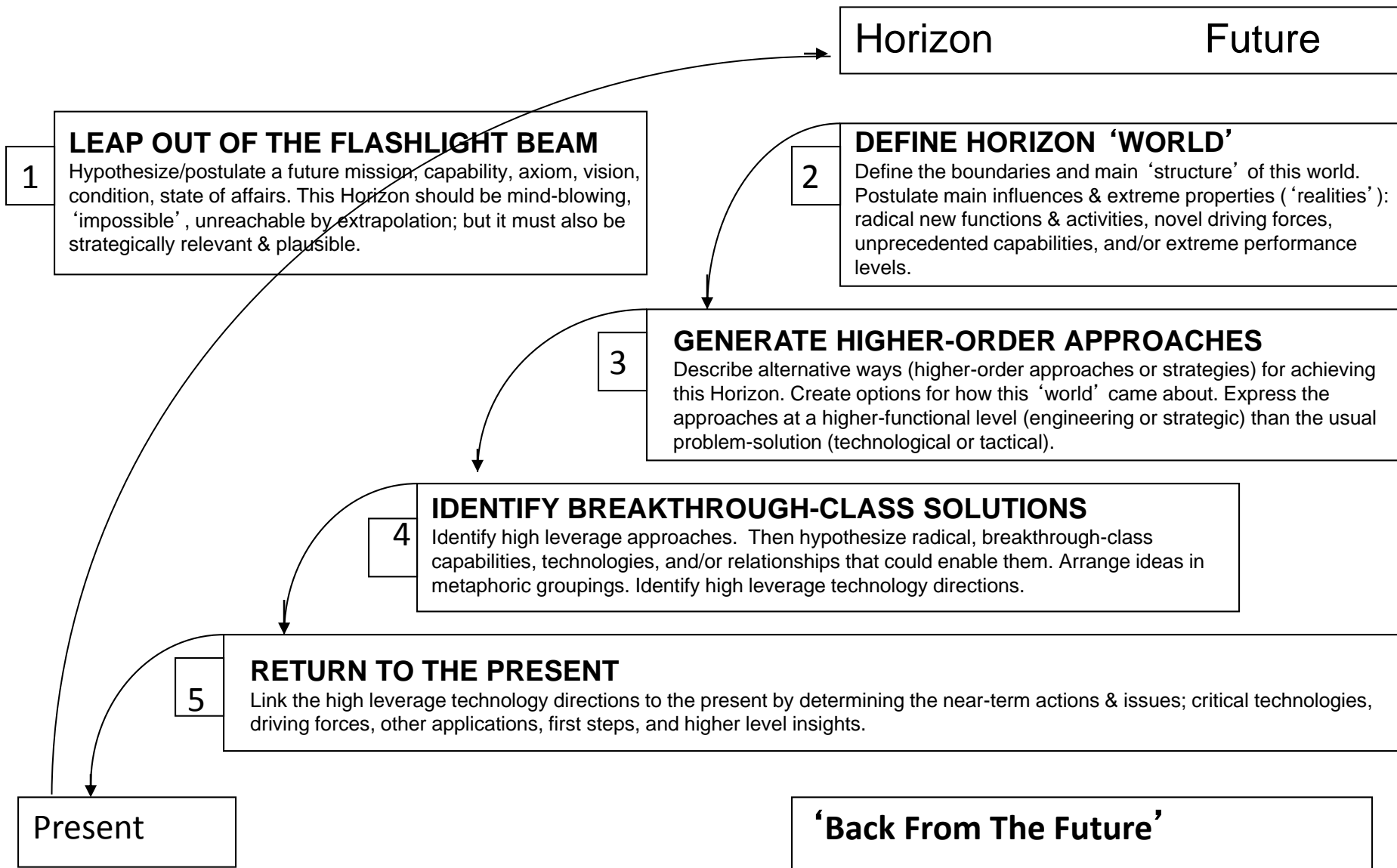
**Invent the safe UAV transportation system
and associated industries/businesses for that country,
given that information technology is the primary instrument**

Horizon “Mission” #2 - Year 2025

- Through innovative alliances, the U.S. has been transformed by a new UAV aeronautical transportation system
- This is analogous to the establishment of an alternative roadway system - The Interstate Highway System - 50-60 years ago
- The projected increases in UAV aircraft flights are on track - and the new UAV transportation system is operating at 50% capacity

Design the safest maximum capacity UAS transportation system of tomorrow

Steps of the Horizon Mission Methodology



Step1 - Horizon Definition

LEAP OUT OF THE FLASHLIGHT BEAM

Hypothesize/postulate a future mission, capability, axiom, vision, condition, state of affairs, metaphor.

This Horizon must leapfrog current problems/issues. It should be mind-blowing, 'impossible', unreachable by extrapolation; but it must also be strategically relevant & plausible (no fantasy or utopia).

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Step 2 - Construct the World

DEFINE THE HORIZON 'WORLD'

Enter a Time Machine. You are to invent this future.
You have the license to speculate.

Define the 'structure' of this world. Postulate main influences & extreme properties ('realities'): radical new functions & activities, novel driving forces, unprecedented capabilities, and/or extreme performance levels.

Step 3 - Think Within New World

GENERATE HIGHER-ORDER APPROACHES

Invent what you mean by this Horizon. Define this world more thoroughly (sub-elements). What's missing from complete description?

Describe alternative ways (higher-order approaches or strategies) for achieving this Horizon. Create options for how the 'world' came about. Express the approaches at a higher-functional level (engineering or strategic) than the usual problem-solution (technological or tactical).

Steps 4 - Identifying Critical Enablers

IDENTIFY BREAKTHROUGH-CLASS SOLUTIONS

Identify ideas/concepts with greatest paradigm difference, maximum newness. What must be overcome? What fundamental changes are required?

Identify high leverage approaches. Then hypothesize radical, breakthrough-class capabilities, technologies, and/or relationships that could enable them. Arrange ideas in metaphoric groupings. Identify high leverage technology directions.

Step 5 - Return to the Present

RETURN TO THE PRESENT

Link the high leverage concepts/directions to the present by determining near-term actions & issues:

- New functions and capabilities
- Critical perspectives
- Requirements for extreme performance
- Applications and alliances
- First step
- Drivers (motivating forces) for precursor steps
- Programmatic and strategic thrusts
- Higher level insights.

Wrap-Up and Follow-On Activities for scenario based planning efforts

- Roll up inputs and come up with “golden nuggets”
- Draft revisions to scenarios (if required)
- Be sure these scenarios fit well within the transportation goals of these countries. (If not, policies may need to be adjusted)

This is the end of my tutorial.

Are there any questions ?

**If time permits, I have some
Backup slides that we can cover.**

Backup Slides

Backup Slides

Message for the NASA Administrator

Opportunities for Innovation

In April 2013, I sent a message to the entire workforce entitled "**Preparing Our Workforce for the Future.**" One of the memo's main points was to acknowledge barriers to innovation and collaboration across the agency and to communicate to line and project managers my expectation that they take an active role in developing and preparing our workforce for the future. This includes employees being allowed to take part in innovative efforts related directly to current and expected future projects, or to the overall mission. Specifically, I expect that project managers will allow flexibility within their existing charge codes to support these opportunities.

Backup Slides

I understand that it is unrealistic, impractical, and perhaps counterproductive to set aside a specific percentage of time for every employee to engage in innovative activities. However, I believe that both employees and their supervisors have a responsibility to engage with each other to discuss opportunities, capitalize on each individual's unique skills, and carve out time for everyone to engage in innovative activities where it makes sense. For some, this might mean establishing a specific percentage of time for engaging in innovative efforts. For others, it might mean helping employees push the boundaries within their current job assignments to find ways to do their work better, suggest improved/streamlined processes, or identify better business practices. For those employees matrixed to other organizations, I encourage project managers, employees, and their supervisors to engage in meaningful joint conversations to find ways to maximize each individual's contributions.

Backup Slides

We have some great examples of where this is happening now. Our "Lean Forward/Fail Smart" award highlighted great efforts employees are making to push boundaries, not be afraid to fail, and apply their learning to accomplish great things. I encourage you to take a look at what the winners have done to build an organizational culture that encourages and practices creative and innovative behaviors.

Backup Slides

Despite the good work already being done, I believe there is more that can be done to help every employee feel that they have the opportunity to be innovative. It is critical to NASA's identity that we constantly push the boundaries of what humans believe is possible. We need to be forward leaning and looking at new technologies and cutting edge solutions. Every employee plays a unique role in shaping our workforce identity and helping create those solutions across the agency.

Together, we're strengthening NASA's legacy of innovation and excellence, and I need each of you working with me to build our future. Thank you for your partnership in this effort.

Charlie B.

Abstract provided to:

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